Smart and Enegy Efficient Power Saving System in University Based on Wireless Sensor Network

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Smart and Energy Efficient Power Saving System Based on Wireless Sensor Network

Thesis submitted in partial fulfillment
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Master of Technology
in
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by

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Dedicated to

My inspiring Parents and Sister

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Certificate

This is to certify that the work in the thesis entitled " ***Smart and Energy Efficient Power Saving System in University Based on Wireless Sensor Network***" submitted by ***Monika Lakra*** is a record of an original research work carried out by her under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of Master of Technology in Computer Science and Engineering, National Institute of Technology, Rourkela. Neither this thesis nor any part of it has been submitted for any degree or academic award elsewhere.

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Monika Lakra

Abstract

In today's world power management plays a very significant role in reducing the power consumption and the efficient utilization of the available resources. In the traditional system, due to the manual operation of the different electrical appliances in the university gets un-attended, and that leads to the maximum wastage of the resources such that the different appliances operating during off-peak hours without any need or requirement and also the street lights remains burning with full intensity during off-peak hours and zero traffic hours. In order to overcome this problem, we we have designed a "smart and energy efficient power saving system", where every rooms as well as every devices are equipped with passive infrared sensor (PIR) which responds the occupancy, and correspondingly devices are controlled automatically. All the street lights are controlled using real time clock (RTC), and the studies astronomical data from Indian Meterological Department and the traffic is detected using the laser according to which the street lights burns with full intensity during peaks hours and with reduces intensity during off-peak hours. Also, a traffic based switching is incorporated for efficient utilization of resources during off-peak hours. There is a secure wireless data transmission methodology used for data transmission from sink to the base station. The entire system is monitored and controlled by the central base station.

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Chapter 1

Introduction

The wireless sensor network are networks in which autonomous wireless sensor node are spatially distributed across a geo-graphical region to monitor physical and environment conditions such as temperature, pressure, sound, light, motion etc. The sensor nodes works with each other to get some events from surroundings and the data gathered from each sensor node are transferred to the base station for further processing in-order to process the required result. The wireless sensor network is built of various sensor nodes which is also called as Motes, basically consist of one or more radio, analog circuit, microcontroller, battery power, sensor interface etc. Each motes have sensing, computing and communication capabilities.

As shown in the figure. 1.1 wireless sensor nodes are scatted in distant geo-graphical location. Each of these sensor node have the capability to detect and route the data

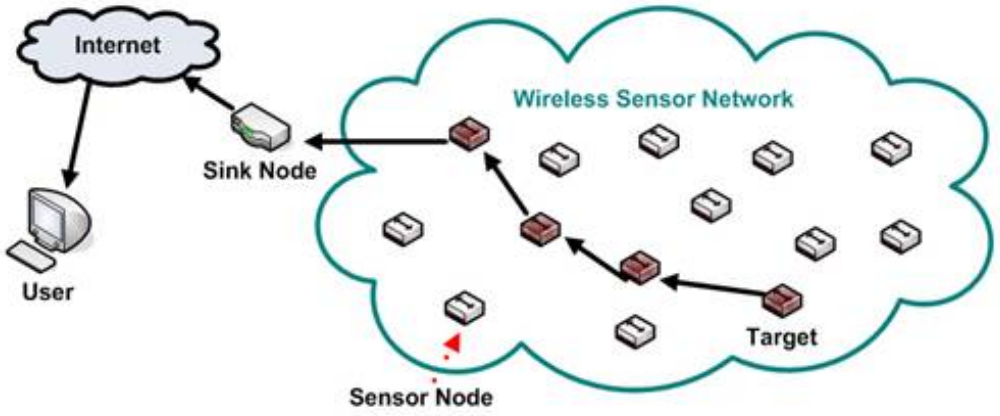

Figure 1.1: Wireless Sensor Network

to the sink and from sink to the users. The protocol stack used by the sink and all the distant located wireless sensor node consist of application layer, transport layer, network layer, data link layer, physical layer, power management plane, mobility management layer, and task management plane. The transport layer helps to maintain to flow of data. The network layer is responsible to route the data received from the transport layer. The power management plane is responsible to maintain how the power is used by the sensor nodes i.e., the sensor nodes should turn off after receiving the data in-order to avoid the duplicate the data and when the power level to any sensor node goes down it should inform all its neighbor node that it cannot participate in the routing the data. The mobility management plane is responsible the detect the movement of the sensor node and provide the ability to maintain the track of its neighbor node. The task management plane balance and schedule the task of various sensor node in specific areas.
There are two type of WSN:

- Structured WSN
- Un−structured WSN

An unstructured WSN is the one which a dense collection of sensor node, which once deployed can be left unattended to perform its monitoring and communication function. Unstructured WSN are homogenous with respect to node type and thus they have no physical hierarchy. And in this there is no mechanism of out-of-band communication. The advantage of a structure network is that fewer nodes are firstly deployed with the lower maintenance and cost. And then the remaining nodes the deployed since the previously deployed nodes are placed at specific location in-order to provide coverage [15, 17].
Sensor nodes can be deployed in one of the following two ways: [5]

- Sensors can be positioned far from the actual phenomenon.
- Several sensors that perform only sensing function can be deployed. They transmit time series of the sensed phenomenon to the central nodes where computations are performed and data are fused.

Since there, are large number of sensor nodes densely deployed i.e., the neighbor nodes may be very close to each other. Therefore multi-hop communication in

WSN is expected to consume less power than traditional single hop communication network. One of the most important constraints on sensor node is the low power consumption required because the sensor node carries limited and irreplaceable power source [5]. Hence, sensor nodes are resource restricted like low power, storage, communication and computation capability.
The application area of the wireless sensor network is where it becomes difficult and important to observe or monitor the environmental condition, health of instruments, home, military, machine in the industry, and other commercial areas.
There are various factors that WNS such as fault tolerance, scalability, product cost, operation environment, sensor network topology, hardware constraint, transmission media and power consumption [5].

1.1 Motivation

For the development of nation, availability of energy and its efficient utilization plays a very signification role [1]. And hence the power saving and its efficient utilization becomes a burning issue. It is a common phenomenon that electricity is wasted in the traditional lighting system where the various lighting devices burns with full intensity throughout the day without any need or requirement. There is a big gap between the energy supplied and its requirement . So, our aim is to overcome this gap. According to the survey of author [4] 12,500 kWh energy is wasted per year by 40 classroom in the university with 270 working days, and according to the author [12] if there are 200 classroom in the university then annually 243000kWh energy is wasted. And according to the statics, in 2005 shandong university electricity fees was 10,470,000 Yuan of which, lighting accounts to 40% of the total power consumed and remaining energy is wasted due to the remained un-attended. And this consumption goes on increasing yearly.
Here is a case study of NIT Rourkela tabulated in table 1.1, of amount of energy being used and the amount of energy required.
So, here our aim is to utilize this wasted amount of energy in an efficient manner.

Table 1.1: A Case Study of Energy Consumption in NIT Rourkela, India

Average time of lectures in any classroom per day	5 hrs
Average number of classes running simultaneously	60
Time for which the electricity supply remains ON in each room/hall	8 hrs
Average load per class	14.4 kWh
Average electricity loss per day per class (for 3 lectures per day)	6.15 kWh
Loss for 60 class per day	369 kWh
Loss per month	8118 kWh
Loss per year (220 working days)	81180 kWh
Total Street light/corridor	180
Average power consumed per day	324 kWh
Average power consumed per month	9720 kWh
Average loss per month	1296 kWh
Average loss per year	15552 kWh

1.2 Problem Statement

In educational institute, a huge amount of energy is wasted in different class rooms, corridor lamps, and street lights lamps etc. Because different electronic devices in class rooms remain un-attended , as well as the street lights lamps / corridor lamps burns with full intensity, even during off-peak hours and this leads to the long burning hours of different electronic devices even during the off-peak hours or when there is no occupancy. This leads to the maximum wastage of energy and this huge consumption of electrical energy goes on increasing yearly .

1.3 Our Contribution

In-order to control the energy wastage in different rooms of the university, the door of the various rooms are equipped with the PIR sensor in-order to count the number of people entering and leaving the room and that data is communicated securely through the secure channel via wireless RF module to the web server where are data is stored, managed and can be viewed through the GUI. Every electronic appliances inside the room are also equipped with PIR sensor which helps to control the switching of these electronic according to the occupancy and requirement. And

these PIR sensor are control according to the instruction given by the particular sink.
And the street lights are controlled according to the astronomical data collected from the Indian Meteorological Department (IMD) [2] and using Real Time Clock (RTC). And during off-peak hours traffic is detected using laser as well as the complete switching of these lights between different intensities is controlled by the central base station (web server).
All the sensor sends their data to their respective sinks and the sinks performs its operation and forward the data to the central base station where the status of various room are stored and can be viewed. In order to maintain the integrity of data send and received, a secure encryption key generation algorithm is used, which generate a unique key for every communication, and this secure encryption key is used by the sender and the receiver for data encryption and decryption purpose for maintaining the integrity of data.

1.4 Thesis Organisation

Following this introduction, the remaining part of the thesis is organized into following chapters: Chapter 2: This chapter deals with the Literature Review. Chapter 3: This chapter deals with the Hardware Model of the entire system. Chapter 4: This chapter deals with the Software System Model of the system. Chapter5. This chapter deals with the Conclusion and Future Work.

Chapter 2

Literature Review

The economy of any country mainly depends on the energy utilization in different field of science and technology. Hence, power saving plays a very significant role in the development of any nation. A huge amount of energy is wasted in education institute, The author of [4] analyzed the Aligarh Muslim Universities energy profile, according to which the energy is wasted in an enormous amount in the university class room, street lights etc. Because 66% of the total energy is consumed by offices, class room, streetlights and the remaining energy i.e., 22% is consumed by staff quarters, hostel and loss lines. And this energy consumption can be reduced in an efficient manner through various methods such as use of time scheduling device for power supply, use of BEE star rated electrical appliances, use of energy management device based on image processing, use of energy renewable energy resources, focus on green building, replacing the chokes and regulator of tube lights and fans, replacing incandescent bulbs with LEDs and CFLs, installing efficient heating and cooling system, implementing exterior lights control scheme etc.

According to the study of the Shandong University, the author of [12] power consumption of lighting account to 40% of the total power consumption and of which 70% of the power gets wasted due to delayed turning OFF or unrequired turning ON. And to overcome this problem the author of [9, 12, 13] have designed automatic light controlling system according to the occupancy as well as by measuring the current illumination of the room. Since every device is equipped with PIR sensor to detect the occupany and according to the data received from any particular sensor node the respective loads switching is controlled.

Since the passive infrared sensor (PIR) are only capable to detect the presence of the human being but not capable to decide the direction of motion. Hence the author of [7, 18] have introduce the concept of the dual sensor in-order to decide the direction of movement and counts the number of person passing the field of view of the dual sensor in different direction.

A huge amount of energy is wasted in the street lights where the street lights burns with full intensity even in the absence of the traffic. In-order to overcome this problem, the author of [11] have designed the WSN to remotely control the street lights lamps and its intensity according to the data received from the Doppler sensor. And the author of [3] have utilized fuzzy logic methods for vehicle, human detection , and error reduction due to the variance in the nature the signal being received/transmitted.

The author of [8] have designed the time based intensity control of the street light. In this the astronomical data collected for different geographical location are used to control the intensity of the street light lamps using real time clock (RTC). The author of [6] have designed a device for detecting the vehicle that consist of a sensor along with the Doppler effect and observed that the Doppler sensor is less prone to false alarm than PIR sensor. And this system is also responsible for detecting the malfunction which is reported to the central base station which helps to reduce the maintenance the cost of the steer light lamps. And the author of [10] control the switching of the street light lamps through the decentralized manner, based on the time of day, environment condition, or by a fixed operational schedule.

Intelligent street lighting system by author [14] remotely control the street light during various peak and off-peak hours, can also tackles the problem of power theft, and also responsible to handle the unpredictable climatic change. Because here, the street lights are equipped with autonomous device which is responsible to monitor the various climatic such as sound, fog, temperature, and carbon mono-oxide emission.

2.1 Conclusion

In this chapter, we have studies the present scenario of the available energy consumption system and the problem associated with them using different technology such as controlling the street lamps using the sun light intensity, class room devices are controlled using PIR sensor etc.

Chapter 3

Hardware Description

3.1 Introduction

Figure.3.1 represents the block diagram of the entire system, where the Ethernet Shield is connected with ATMEGA to facilitate the web server and the storing the data in a secure manner via secure channel using the secret encryption key standard in order to maintain the correctness of the data being send and received from different sink to the web server and vice versa.
SN(1) to SN(n) represents the number of dual sensor node installed in every entrance of the room, to detect the occupancy of the room, CD(1) to CD(n)/SL(1) to SL(n) represent the number of sensor nodes installed in street lights/corridor lamps in order to detect the present traffic to control the switching between different intensity according to the different condition and the demand of traffic. The sensor nodes in corridor lamps comprises of passive infrared sensor (PIR), RF transmitter etc, and the sensor nodes in the street light lamps comprises of laser to measure the distance of traffic, and the Rf transmitter etc. Here RTC is used to provide the current date and time to the server without any failure. Driver circuit to control the switching between different intensity and driver circuit driver circuit to drive the loads of different class room according to the instruction given by the sink. And LCD is used to display the current occupancy of the room.

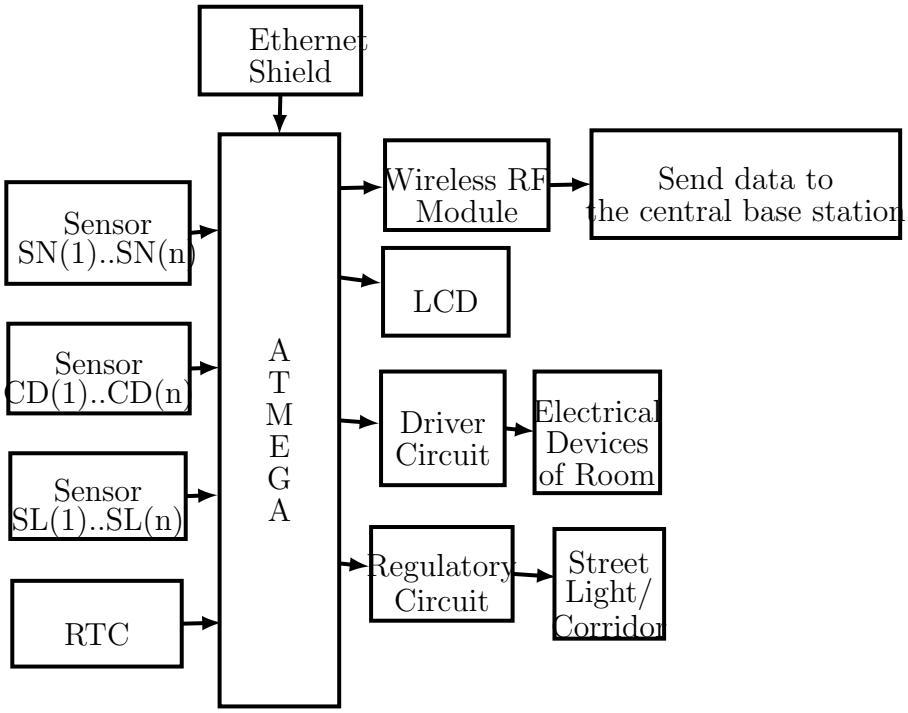

Figure 3.1: Block Diagram of the System

3.1.1 Micro controller

Here, we are using Arduino Uno as the micro-controller which belongs to the ATMEGA328P family. The system provides the set of analog and digital input and output pin through which can be used for interfacing with different circuits or another boards. It has 16 digital input/output pins out of which 6 pin can be used for pulse width modulation (PWM) at about 500Hz frequency, 6 analog input/output pins, a 16 MHz crystal oscillator, a USB connection for burning the command from arduino GUI software to arduino board, a power jack, a in-circuit serial programming (ICSP) header of provides the ability to logical device, micro-controller, or other embedded devices to be programmed while installed in the computer system and provides the ability of easily burning the command from computer system to arduino micro-controller, and a reset button which is used to refresh or erase the memory. Its operating voltage is 5V. Arduino uno has a 32KB of flash memory to store the command, 2 KB SRAM, 1KB EEPROM.

3.1.2 Real time clock

Real time clock (RTC DS1307) is a low power, full binary coded decimal (BCD) clock/calender. Data transfer takes place through i^2c bidirectional bus. The DS1307 has a in-built power supply circuit that detect the power failure and automatically switches to back battery power embedded in DS1307. IT has 56 Byte, battery backed, non-volatile RAM for data storage. And it consume less than 500nA in battery back up mode with oscillator running. It is used to provide the current date and time to the arduino uno micro-controller since, it counts second, minute, hours, date of the month, month, day of the weak, and the year including leap year.

3.1.3 Liquid crystal display

LCD is a type of display used in digital watches and many portable computers. LCD displays utilize to sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through.
Liquid crystal display (LCD 16x2) is a parallel interface means the micro-controller (Arduino uno) have to control several pin at a time in order to control the display of the LCD. Here, the alphanumeric 16x2 signifies the size of the LCD display, 16 characters per line and there are 2 such lines requires 8 data lines, 3 control signals, and they are interfaced to 3664.The LCD has two register : command register and data register. The command register stores the commands given to the LCD where as the data register stores the data to be display on the LCD display. The process of controling the display in the LCD display is putting the data that forms the image of what you want to display on the LCD display into the data register, and then putting the required instruction into the instruction register. The LCD display can be controlled in two modes : 4− bit and 8−bit. But here we are working on 4-bit which requires 7 input/output pins from the arduino to display the processed data on the LCD screen. In LCD each character is displayed in 5x7 pixel matrix.
Passive infrared sensor (PIR) measure the infrared (IR) lights radiated from the objects in its field of view. Passive word signifies that the sensor does nor reflect or radiate any infrared lights for detection purpose as infrared (IR) sensor. PIR sensor

entirely works by detecting the infrared lights emitted or radiated from different objects. In the PIR sensor, we can adjust the sensitivity as well as the delay of the PIR sensor. Sensitivity of the PIR sensor can be increased by rotatiny the sensitivity pin in a clockwise direction and can be decreased by rotating in anti−clockwise direction. A fresnel lens above the PIR sensor is plano convex lens which used to provide the wide range of coverage for the PIR sensor.

3.1.4 Ethernet Shield

The Ethernet Shields facilitate the arduino uno boards (micro controller) with the internet facility and an ethernet shield also have in−build SD card for reading and writing data. It works on the Wiznet W5100 ethernet shield, which provides a network (IP) stack capable of UDP and TCP. The Ethernet Shield has a standard RJ−45 connection, with an integrated line transformer and a power. Arduino uno communicated with both W5100 and SD card using serial peripheral interface (SPI).

3.1.5 Embedded System

An embedded system is a computer system designed for dedicated functions for controlling the larger system, often with the real-time computation constraints. It is embedded device often include hardware and mechanical, software computation etc. By contrast, a general-purpose computer, such as a personal computer (PC), is designed to be flexible in order to meet a wide range of end-user needs.

3.1.6 EXAMPLES OF EMBEDDED SYSTEMS

Coming to examples, now−a−days each and everything are the example of embedded systems. Such as given in the figure.3.2.

Digital Water Heater Here temperature is the variable to be processed and it is the input is to be given by the users. Controller will take care on the controlling

Figure 3.2: Example of Embedded System

the commander action and will take care of the desired process.

Microwave Oven Here again temperature will be the variable to be processed. Same controlling action will be performed by the controller in order to accomplish the command .

Daily used devices Braking System, Tire Pressure Monitoring System, Music Player, Airbags, Power Windows, GPS, and Car braking system can be an instance, it shows the real time and reactive behaviour of the embedded system. Brake would be applied at any point in time, but still it would stop the car. All gym equipment from treadmill to cycling equipment are example of embedded systems.

Entertainment Video games, all digital machines, I pod, MP3/MP4 players, Xbox, Remote (controller) of TV, Telephone with memory, display and other sophisticated features.

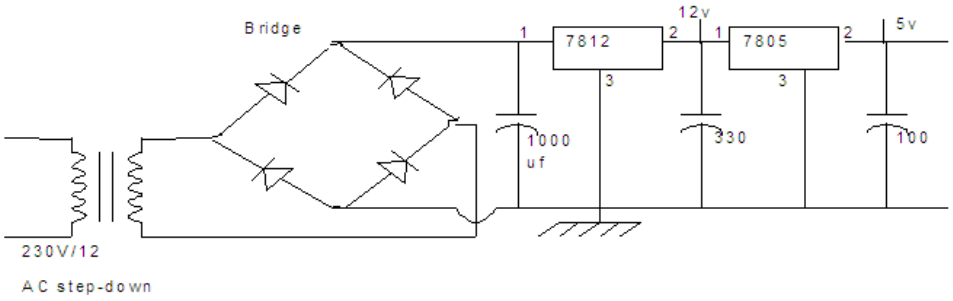

Figure 3.3: Power Supply Circuit

Motor controls Systems For example, an accurate control of speed and position of d.c. motor, robot, and CNC machine, the automotive applications like such as a close loop engine control, a dynamic ride control, and an anti-lock braking system monitor are all examples of embedded system.

3.2 Power Supply

3.2.1 Power Supply Circuit

Any new invention cannot be activated without the power supply. All the electronic components starting from diode to various ICs, all work with a DC supply ranging from 5V to 12V. We are utilizing the same for the cheapest and commonly available energy source of 230V−50Hz and stepping down, rectifying, filtering and regulating the voltage.

3.2.2 Transformer

A bridge rectifier coupled with a step down transformer is used for our circuit design. The voltage rating of transformer used is 0−12V and the current rating is 500mA. When AC voltage of 230V is applied across the primary winding an output AC voltage of 12V is obtained. One alteration of input causes the top of transformer to be positive and the bottom to be negative. The next alteration will temporarily

cause the reverse.

3.2.3 Rectifier

In the power supply circuit, rectification is normally achieved using a solid state diode. Diode has the property that will let the electron flow easily at one direction at proper biasing condition. Bridge rectifiers of 4 diodes are used to achieve full wave rectification. Two diodes will conduct during the negative cycle while the other two will conduct during the positive half cycle. A rectifier is a electrical devices that coverts alternating current (AC) to direct current (DC), which can flow only in one direction and this complete process is called as rectification.

3.2.4 Filtering Unit

Filter circuit is a capacitor that acts as a surge arrester always following the rectifier unit. This capacitor is also called as a decoupling capacitor or a bypass capacitor, is used not only to short the ripple with frequency to ground but also leave the frequency of the DC to appear at the output.

3.2.5 Regulator

The voltage regulator is designed in such a way to automatically maintain a constant level as per the need. The voltage regulator play an important role in any power supply unit. The primary purpose of using regulator circuit is to aid the rectifier and filter circuit, providing a constant required DC voltage to the device. Power supplies without regulators have inherent problem of changing DC voltage values due to variations in the load and due to fluctuations in the AC line voltage. With a regulator connected to DC output, the voltage can be maintained within a close tolerant region of the desired output. Here, IC 7805 and 7812 regulators are used in our system for providing the required DC voltage of +5V and +12V respectively.

3.3 Wireless RF Module

The RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna. The transmission occurs at the rate of 1Kbps−10Kbps. The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter RF module.

3.3.1 RF Transmission

RF refers to the frequencies that fall within the electromagnetic spectrum associated with radio wave propagation. When applied to an antenna, RF current creates electromagnetic fields that propagate the applied signal through space. Any RF field has a wavelength that is inversely proportional to the frequency. 433.92 MHz falls into the Ultra High Frequency (UHF) designation, which is defined as the frequencies from 300 MHz 3 GHz. UHF has free-space wavelengths of 1 m 100 mm. This means that the frequency of an RF signal is inversely proportional to the wavelength of the field. The Parallax RF modules utilize a frequency of 433.92 MHz; this works out to be a wavelength of approximately 0.69 meters.

3.3.2 RF Receiver

The RF receiver section, receives the RF signals with the help of antenna. These signals are decoded and sent to the microcontroller. The receiver module requires no external RF components except for the antenna.

3.3.3 nRF24L01

The nRF24L01 is highly integrated,low cost single chip 2.4GHz RF transceiver, RF synthesizer, and a base band, worldwide license free, 1Mbps and 2Mbps on−air

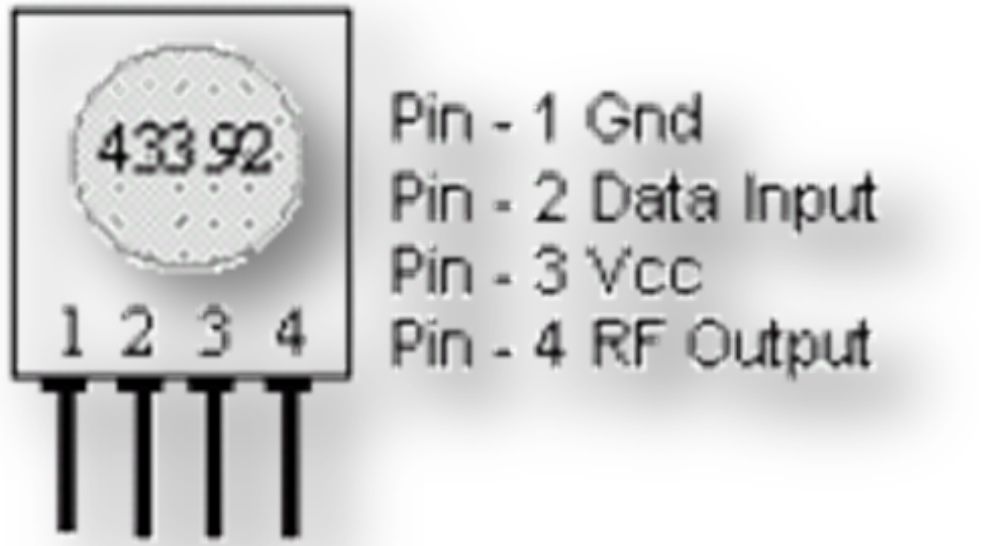

Figure 3.4: RF Transmitter

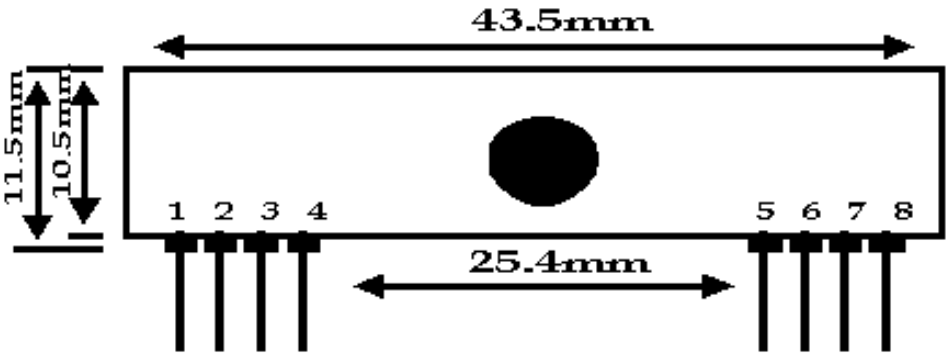

Figure 3.5: RF Transmitter

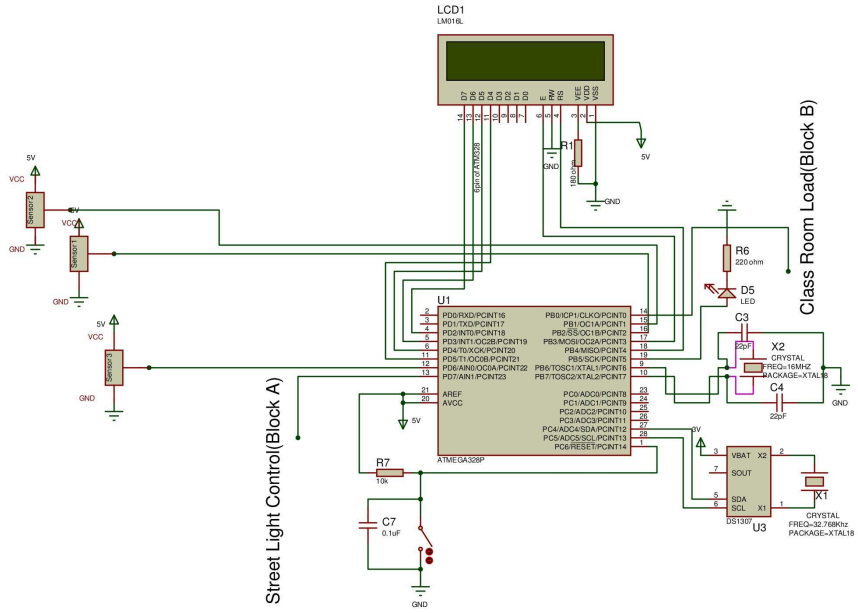

Figure 3.6: Circuit Diagram of the Entire System

data rate. nRF23L01 is used for two−way communication.

3.4 Circuit description

The below figure 7.is the schematic diagram of hardware controlling the various electronic devices as well as the street light/corridor lamps in the university. U1 (ATMEGA328P) is the central processing unit of the system, controlling the entire system. Here, the three PIR sensor are connected to 12, 15, 16 of U1, of which two is used to detect the occupancy of any room according to the different direction of movement and other is used to detect the traffic condition in the street light scenario.

A 16x2 liquid crystal display (LCD1) to connected to U1 that shows the occupancy of any particular room. LCD1 with pin 4, 5, 6 as control signal pins are connected to pin 18, 8, 17 of U1. In order to give command to the LCD1 to perform its task, its data pin 11, 12, 13 and 14 are connected to pin 11, 6, 5, 4 of U1.

RTC provides real date and time to the central base station, where is serial data

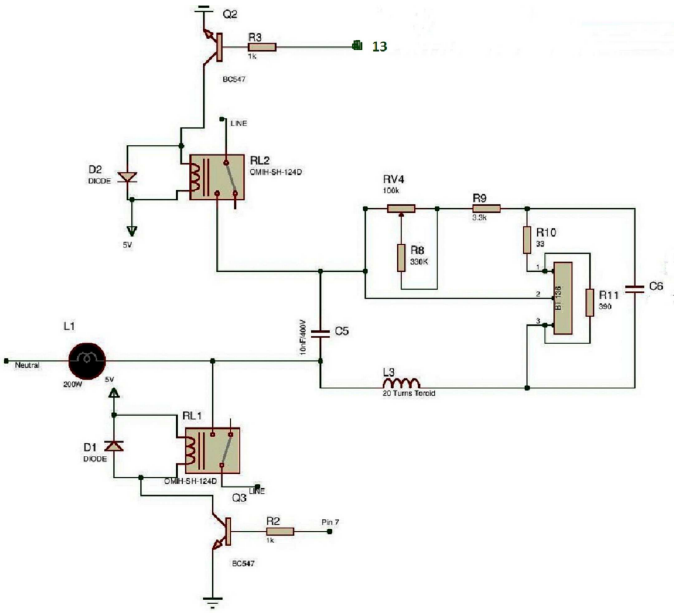

Figure 3.7: Block A

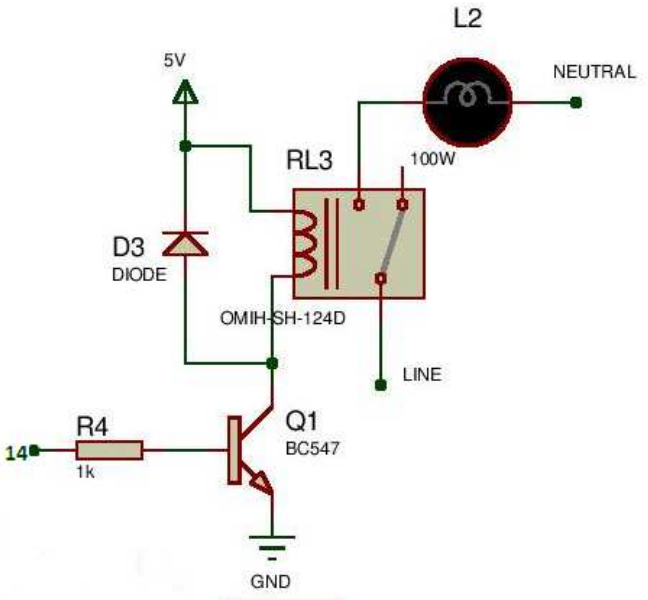

Figure 3.8: Block B

(SDA) pin at 5 is connected to 27 and its serial clock pin at 6 is connected to 28 of U1.

The figure.3.7, the block A represents the regulatory circuit controlling the street light/corridor lamps intensity. In which the relay (RL1) is used to control switching of the lights where as the relay (RL2) is used to control the different intensity during different condition using BT136. The entire is carried out by the ATMEGA328P.

The figure.3.8, the block B represents the driver circuit which is used to control the loads in the rooms using a relay (RL3) driven by a transistor, in which the switching takes place according to the instruction given by the U1.

3.5 Conclusion

In this chapter, we have designed the hardware section of our work, using various available components such as micro controller, RTC, LCD, Ethernet shield, and the power supply of the entire system, wireless data transmission module and the description of the entire circuit.

Chapter 4

System Software Description

4.1 Introduction

Figure.4.1 shows the system architecture of the entire system. In which the every load is equipped with a sensor node on the condition that the original lighting system remains unchanged, and then adjusting the perception range of the sensor which is 120 degree for passive infrared sensor such that to avoid the interference between the sensors of different nearby loads. Every sensor node perceives the human signal, which is used to control the light. Every class room is equipped with a individual sink. And there is a communication between the sensor node and the sink, hence each sensor node sends the status of each node to the sink to control the electronic devices of the room and these sink is connected with the internet and all the sink of the different room sends the current status (that is the number of person inside the class room) data to the web server via NRF24l01 and all the information are gathered into the computer (web server). This web server is responsible for integration, gathering of data as well as provides the necessary web services. An authorized person can login in the web server via a networking and can see the current status of different room any time and from any place and can get various details like duration of any room being used with time etc.

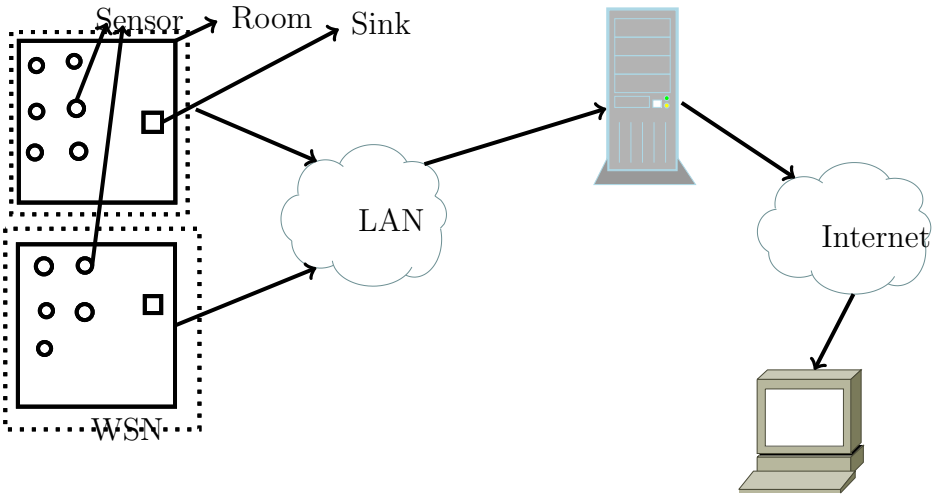

Figure 4.1: System Architecture Diagram

4.2 Controlling the switching of electronic devices in various room

The sensor network is planned to be deployed in the university campus in such a way that, every entrance of the room will be equipped with the dual PIR sensor which is capable to detect the direction of movement of the people and counting the number of person entering and leaving the room and then calculate total occupancy such that the number of person inside the room and send this calculated value to the web server via sink through NRF24l01. In order to control the various electronic appliances, all the electronic appliances are equipped with a passive infrared sensor which detects the human signal and accordingly controls the switching of the appliances such that if the human signal is detected the appliance gets switched ON and remains ON as long as the sensor receives the human signal, if the sensor stop getting any signal from human then wait(maintains a delay) for some fixed time then gets switched OFF automatically.

In order to count the occupancy of the room, one should make the difference between the entry and exit condition. Since the PIR sensor are only capable to sense the presence of human being but not able to make the decision regarding the direction of movement. Hence, we are using the concept of dual sensor in which two sensor are placed in some fixed distance as shown in the figure.4.2

Here, the two sensor SN1 and SN2 are placed horizontally in some constant fixed

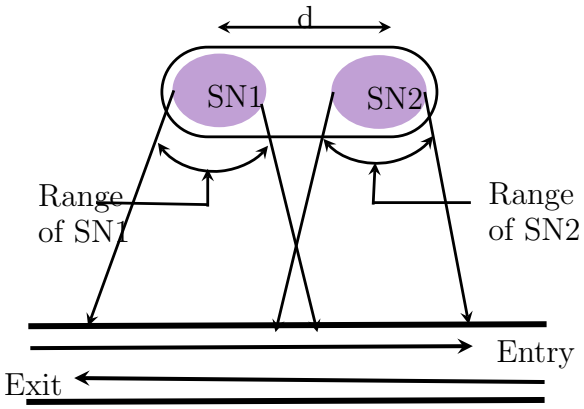

Figure 4.2: Direction of Movement

distance *d*. If the sensor SN1 detects the occupancy first followed by sensor SN2 within the fixed time period then that movement is considered as entry condition where as if the SN2 detects the occupancy first followed by SN1 within the fixed time period then that movement will is considered as exit condition. Here every entry and exit is being counted so, if the occupancy of any room is greater than zero then the counted value is sent to the web server through the sink using NRF24lo1 and that particular room is indicated with yellow color in the web page which can be viewed by the authorized and the counted value is also saved in the database (DB) along with the time at which the data is received by the web server and the rest of the rooms are indicated in green color. Here, the green color in the web page signifies that the class is vacant or the count value is zero for that class.
The PIR sensor installed in every electronic devices are responsible for the switching ON/OFF of these appliances such that, if the sensor installed in these appliance receives the human signal in its perceptive range then that sensor sends the signal to the sink via RF transmitter module and the RF receiver module available at the sink get the data and control the switching of that particular appliance.
Algorithm 4.1 and flow chart in figure.4.3 describes the working principal of counting the number of people entering and leaving the room.

The figure shows the web server page through which the authorized person can monitor the status of different room from any place, at any time via internet connection.

And the figure shows the database of the web server for storing the status value of different room and the time during which the class room is being used. Here, we

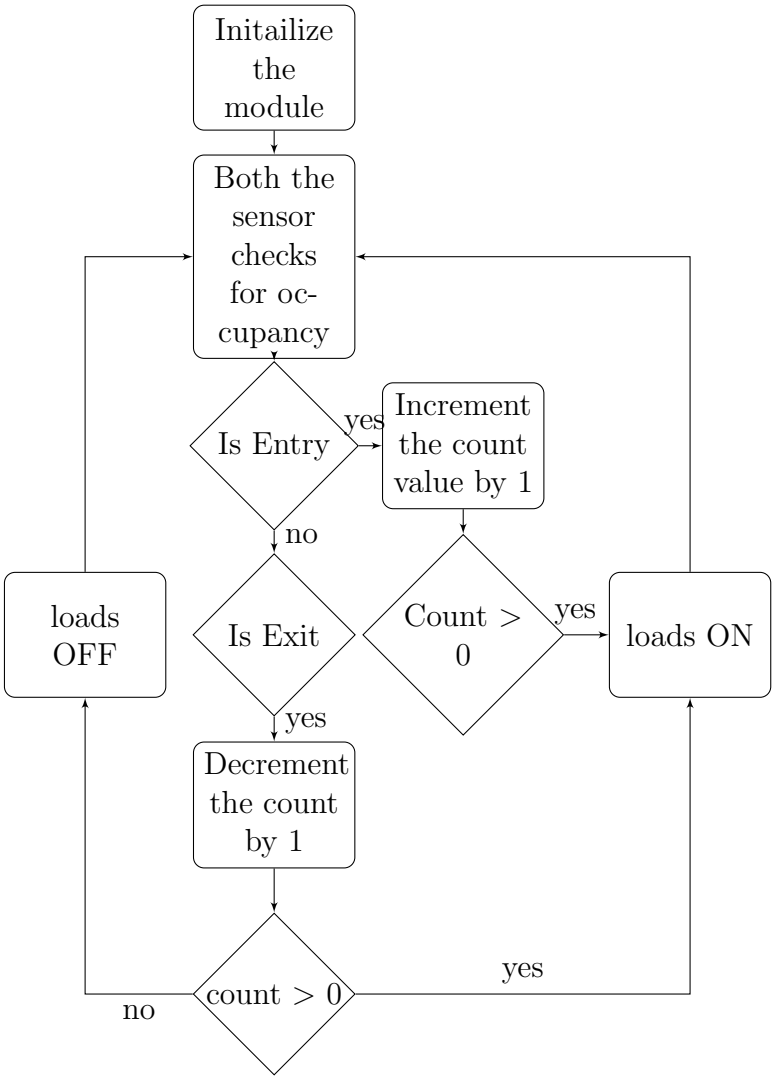

Figure 4.3: Flow Chart of Smart Class Room

Algorithm 4.1: Control the Electronic Devices

```
Result: Initialize the count = 0
Calibrate the sensor node
if any of the two sensor sense the data then
    sends the data to the sink and waits for its consecutive sensor data
    if the corresponding sensor also sends the data within the fixed time period
    then
        Increase or decrease the count value accordingly
    end if
end if
if count == 0 then
    Automatically switch OFF the devices
end if
if count > 0 then
    Automatically switch ON the devices
end if
```

have implement the whole system for one class room and had tested for the same so here is the database of that particular class room.

4.3 Controlling the Switching of Street lights lamps

Street lights are controlled according to the astronomical data of sunrise/sunset of different month studied from **Indian Metrological Department** [2] and a study of peak and off-peak hours is tabulated in table 4.1. And using the RTC DS1307 which communicated via i2c serial communication integrated with a battery power and is responsible to provide the current date and time even if the power failure occurs. Street light lamps burns with full intensity during the peak hours and with reduced intensity during off-peak hours according to the data sent from the web server. During off-peak hours, if there is a detection of traffic via laser, then a particular set of street lights switches from its reduced intensity to its full intensity and remains in the same state as long as the as particular set of street lights gets its traffic cleared, then after resumes to its reduced intensity.

Algorithm 4.2 explains the working of the street lights switching between different intensity under different condition.

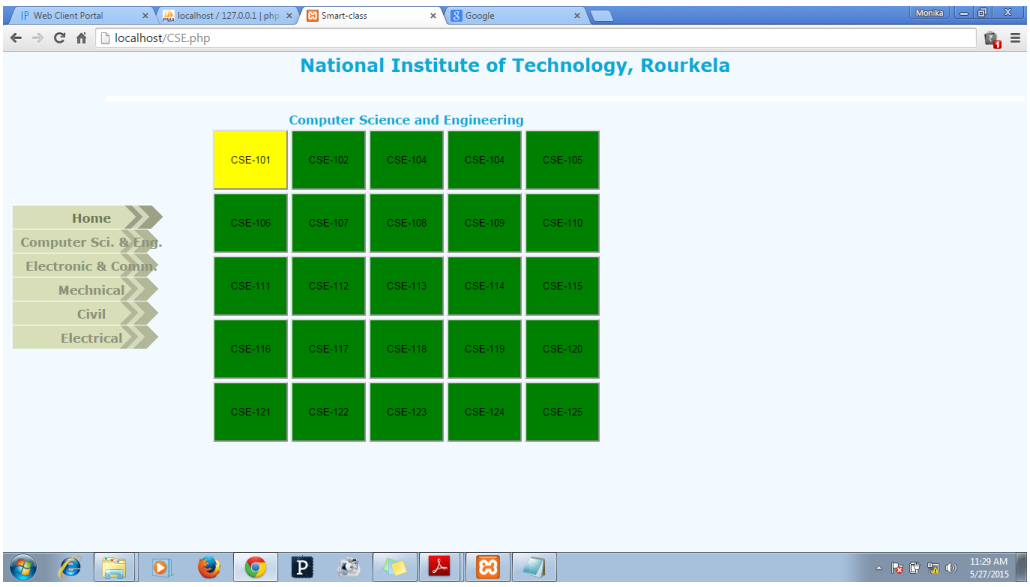

Figure 4.4: Status of different room

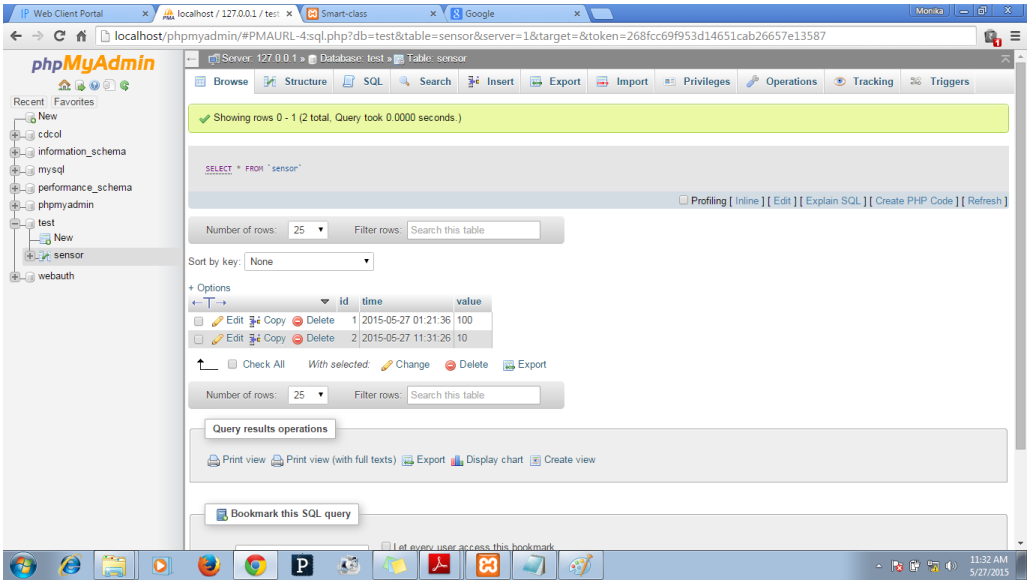

Figure 4.5: Status of different class stored in database

Table 4.1: Studied Astronomical Data

Interval	Approx Sunrise (hh:mm)	Approx Sunset (hh:mm)	Peak hours (hh:mm)	Off-Peak hours (hh:mm)
Apr,May,June, July,Aug	5:00 to 5:45	18:00 to 18:40	18:40 to 00:01	00:01 5:00
Jan,Feb,Oct, Nov,Dec	5:45 to 6:30	17:05 to 17:45	17:45 to 00:01	00:01 to 5:45
Mar,Sep	5:35 to 5:45	17:40 to 18:10	18:10 to 00:01	00:01 to 5:35

Algorithm 4.2: Control the Street Light Devices

```
1: Get the current date and time from RTC
2: if time > peak hour and time < off−peak hour then
3:    Street lights and corridor lamps burns with full intensity
4: else if time > off−peak hour and time < peak hour then
5:    Street lights and corridor lamps burns with reduced intensity
6:    if Any traffic is detected then
7:       Street lights and corridor lamps will switch to its full intensity
8:    end if
9: end if
```

4.4 Data Security

It is a tough challenge to provide security to the wireless sensor network, due to its distributed nature and limited resources. In order to design a secure WSN, secure data transmission should be achieved at every transmitting/receiving node. In our work, there is a need to protect the data from the attacker in the wireless channel. Secure data transmission from sink to the server is a serious issue in our work. Hence, in order to save our data from malicious activity we have added a secure Encryption key generation algorithm between the sink and the server. Every time before the communication begins between the sender and the receiver, a unique encryption key is generated for that particular communication and as the life of the key expires the key is lost and the communication is also lost. The sender encrypt the data with the help of the encryption key and the receiver decrypt the received data with the inverse of the same encryption key. As soon as the communication is completed the encryption key is lost.
According to the author of [16] following various steps are required to be performed to send data securely between sink to server:

- BS assigns a unique *IDs* to the each sink deployed in the network.
- Every time the BS and sink generate a secret encryption key for the communication which is secret between particular sink and the base station.
- This encryption key is used by sink to encrypt the data and the same encryption key is used by the server to decrypt the data.

The algorithm 4.3 is used for the secret encryption key generation for the secure wireless communication.

Algorithm 4.3: Encryption Key Generation

1: BS selects a random number $x \in_R Z_q^*$
2: $R = q^x \ mod \ p$
3: $z = m^w \ || \ R$
4: $s = x + R^z$
5: BS sends (R, s, m^w) to the sensor S_i
6: $Z^* = m^w \ || \ R$
7: $m = R^{Z^*}$
8: **if** $g^s = R.g^m$ **then**
9: proceed to next step, otherwise exit
10: **end if**
11: S_i select a random number y
12: $I_{ek} = y + s + m^{-1}$
13: $y^* = g^y$
14: Sensor S_i sends (I_{ek}, y^*) to the BS
15: Finally, BS calculate the Encryption key E_{nk}
16: $E_{nk} = {y^*}^{-1}.g^{I_{ek}} \ mod \ p$

Correctness of Algorithm

$$
\begin{aligned}
R &= E_{nk} \\
&= {y^*}^{-1}.g^{I_{ek}} mod\, p \\
&= g^{y\text{-}1}.g^{(y+s+m^{-1})} mod\, p \\
&= g^{y\text{-}1}.g^{y}.g^{s}.g^{m^{-1}} mod\, p \\
&= g^{(x+R^z)}.g^{Z^*} mop\ p \\
&= g^{x}.g^{R^z}.g^{R(m_w||R)^{-1}} mop\ p \\
&= g^{x}.g^{R(m_w||R)}.g^{R(m_w||R)^{-1}} mop\ p \\
&= g^{x} mod\, p \\
&= R
\end{aligned}
\tag{4.1}
$$

The sink sends the encrypted data to the BS using the encryption key E_{nk} and the BS can decrypt the received data using the inverse of the same encryption key. So if any vague data comes from the adversary then that cannot be decrypted by the

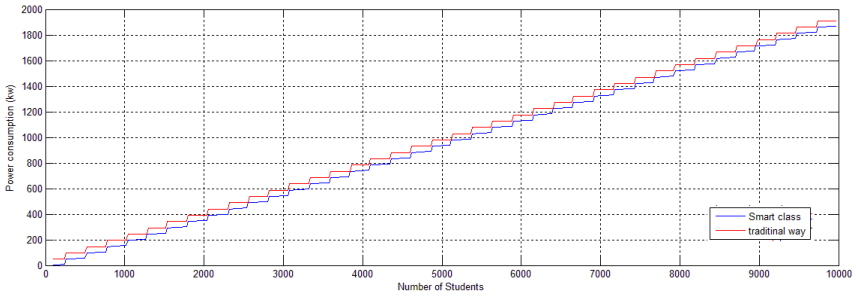

Figure 4.6: Comparison between the energy consumption in traditional system and smart system

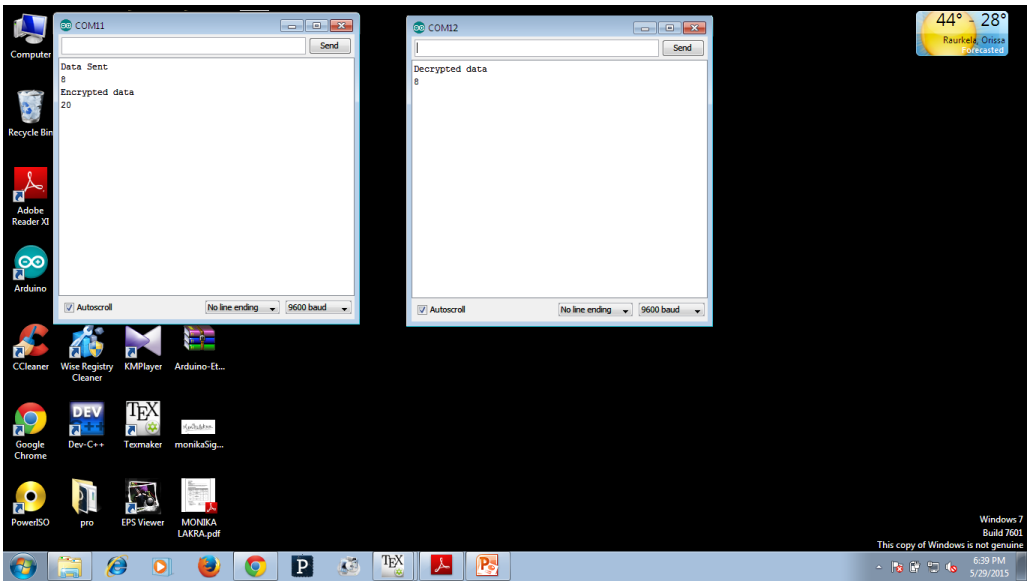

Figure 4.7: Wireless data send from sensor node to the base station

BS and at the same time the BS can neglect the data.

4.5 Simulation

The "smart and energy efficient power saving system" is simulated on arduino uno board. The graph is plotted between Energy consumption and number of students. In this simulation, the following data is used: The figure. 4.7 shows the lossless transmission from distant sensor node over the secure wireless channel to the base station (web server). Here, COM11 is the sender node where as the COM12 is the received node.

Table 4.2: Calculated data for simulation

Average time of lectures in any classroom per day	5 hrs
Number of courses	4
Total strength of a class Fixed load	256 370W
Variable load	130W to 2080W
Strength of student block	4×16

4.6 Conclusion

In this chapter, we have shown the comparison between traditional and the our system "Smart and Energy Efficient power saving system" which will always shows result (energy consumption) less than or equal to the tradition energy consumption system and the complete description of the used algorithm and the secure data transmission methodology.

Chapter 5

Conclusion and Future Work

In this thesis work, an smart and energy efficient power control system provides an innovative technology to save the resources for future and utilize them in an efficient manner. In the traditional system, huge amount of power gets wasted due to lack of feedback mechanism, which determines the need for power resources for particular situations. A more intelligent systems are required to be embedded for monitoring and controlling the power resources as per the requirement, providing a user friendly environment. In this thesis work, We have developed a wireless sensor network using PIR which senses the present situation, as soon as it detects a human being it transmits the information to the central base station regarding the current status. It takes an intelligent decision to control the corresponding devices of the classroom. We have introduced the concept of dual sensor, for identifying the direction of movement of people, and counting the number of people in different rooms of the university and that data is stored in the data base at web server and can also view the occupancy detail of various rooms in the university. An RTC is being integrated with central base station providing the real-time information to control the remote street/corridor lights. A novel technique to control the intensity of light based on astronomical data and traffic conditions, which is determined using a laser detecting system. The overall system incorporates intelligent monitoring and control of power providing an efficient power consumption. This system provides an autonomous control over the different electronic appliances without any human intervention and an efficient utilization of the resources and save the power wastage when compared to the traditional system and is cost efficient as compared to the

product available in the market for the power saving. And for the secure data transmission, an encryption key algorithm is used for key generation for encryption and decryption of data for the secure wireless transmission of data for every new communication at every node (sink).

However, there are few constraints associated with this thesis work which needs to be resolved in the future work. Firstly, the wireless RF module should be replaced with the attiny85 and nrf24l01 wireless module since the wireless module can communicate in a uni−direction while using attiny85 and nrf24l01 we can perform a bi−directional communication. The laser installed in street lights should be replaced with the ultrasonic sensor in order to measure the distance of the fore coming and out going traffic. In the future we expect our work to be extended with more secure wireless transmission methodology and implementation of new algorithm for increasing the smart and efficient utilization of available resources.

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